ZOOPLANKTON COMMUNITIES OF THE MURRAY-DARLING SYSTEM

A Preliminary Report

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ABSTRACT: Data are presented from a continuing study of Murray-Darling planktonic and littoral microfauna, with comparisons from similar studies of large river systems elsewhere. One hundred and twenty-six identified taxa, predominantly Rotifera, Cladocera, Ostracoda and Copepoda are listed, with distributional data. Twelve per cent of these are new genera or species, or new records from Australia. The zooplankton fauna of the river system is seen as a lacustrine assemblage derived principally from upstream impoundments, and inoculated from backwaters and billabongs in time of flood. Slow flow, moderate temperatures (11–28°C) and the still waters of locks and weirs contribute to the persistence of this limnoplankton assemblage in the lower Murray, despite high turbidity.

INTRODUCTION

The importance of the Murray-Darling System as a source of water for multiple use, particularly irrigation and domestic supply, is well-reported, as is the increasingly deleterious effect of such use on water quality. Increasing salinity levels, exacerbated by irrigation practices, and the costly treatment of algal blooms to permit water abstraction for domestic supply are two major problems of the lower Murray.

In view of the importance of the river system to four States, and the vast area of the basin (over a million km^2), it is remarkable that so little information is available on the ecology of the rivers and their impoundments, or on the effects of multiple use on this complex lotic ecosystem.

Extensive reviews of riverine studies elsewhere are provided by Hynes (1970) and Whitton (1975). These sources note the use of aquatic invertebrates, including plankton assemblages, as indicators of water quality. Such data are lacking for the Murray-Darling. Indeed, Bayly and Williams (1973, p. 135) note that 'from the amount of work that has been published on the ecology of Australian rivers and streams, limnologists outside Australia could well be forgiven for thinking that no running water exists here at all'.

The only intensive study to include aspects of invertebrate ecology of the Murray is that of Gutteridge, Haskins and Davey (1974) for the Cities Commission. This study, undertaken in the Albury-Wodonga area, is confined to the area likely to be most affected by urban development of the twin cities: Lake Hume and its environs, and the Murray and its floodplain for a distance of 200 km to Lake Mulwala. The study is further considered by Walker and Hillman (1978).

The present sampling programme was commenced in 1976 to provide baseline ecological information on the invertebrates of the Murray-Darling, with particular emphasis on the potamoplankton. Its aims are: to provide a systematic account of the planktonic fauna of the major impoundments, rivers and tributaries of the system; to assess the characteristic plankton assemblages as indicators of water quality; to provide an account of the complex ecology of billabongs and their relation to the river; and to determine if the autochthonous plankton shows adaptations to the special conditions of the lower Murray, which has high turbidities (Secchi transparency < 10 cm), low and variable flow, and relatively high salinities (up to 1,000 ppm).

MATERIALS AND METHODS

Qualitative samples were taken with standard plankton and Birge cone nets in both horizontal and vertical hauls. Quantitative samples were collected in a modified 30-*l* perspex trap (Schindler 1969).

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Identifications were made of dissected specimens mounted in PVA lacto-phenol, using keys by Bayly (1961, 1962, 1963, 1964), Goulden (1968), Morton (in prep.), Smirnov (1971), and Smirnov and Timms (in prep.).

SAMPLING STATIONS

Fig. 1 and Table 1 show location of sampling stations. Sampling frequency varied from bi-weekly in the lower Murray to monthly or each season in more distant areas of the basin. Stations were selected to enable longitudinal comparisons of faunal composition to be made, and to cover as thoroughly as possible the watershed of each impoundment, major tributaries and downstream river tracts.

RESULTS AND DISCUSSION

Representative data from selected stations only are presented here. A further twelve-month sampling programme is planned. Trends are already clear from data collected, and a reasonably complete checklist of both planktonic and littoral micro-invertebrates can be given (Table 2). In addition to the tabled species, Protozoa (particularly *Difflugia*, *Arcella* and the dinoflagellate *Ceratium*), and a diverse macro-invertebrate assemblage were frequently collected in the

FIG. 1 — Sampling stations on the rivers and impoundments of the Murray-Darling System. Localities are given in Table 1.

TABLE 1
THE LOCATION OF SAMPLING STATIONS SHOWN IN FIG. 1.

Station Number	Locality	Station Number	Locality
1	Murray R., Tailem Bend	27	Murray R., Swan Hill
2	Murray R., Mannum	28	Murray R., Cohuna
3	Murray R., Waikerie	29	Murray R., Echuca
4	Salt Ck., Loxton	30	Goulburn R., McCoy's Bridge
5	Murray R., Renmark	31	Lake Victoria, Shepparton
6	Murray R., Mildura	32	Goulburn Res., Nagambie
7	Darling R., Wentworth	33	Goulburn floodplain, Seymour
8	Darling R., Pooncarrie	34	Goulburn floodplain, Alexandra
9	Lake Menindee	35	Lake Eildon
10	Darling R., Wilcannia	36	Lake Eildon pondage, Eildon
11	Darling R., Bourke	37	Goulburn R., Jamieson
12	Macintyre R., Goondiwindi	38	Howqua R., Howqua
13	Namoi R., Narrabri	39	Lake Mulwala, Yarrawonga
14	Keepit Res.	40	Ovens R., Wangaratta
15	Macquarie R., Dubbo	41	Ovens R., Bright
16	Burrendong Res.	42	Ovens R., Harrietville
17	Macquarie R., Bathurst	43	Murray floodplain, Wodonga
18	Bogan R., Nyngan	44	Lake Hume
19	Wyangala Res.	45	Kiewa R., Tallangatta
20	Eumarella Ck., Bredbo	46	Murray R., Corryong
21	Burrinjuck Res.	47	Rocky Valley Dam, Falls Ck.
22	Murrumbidgee R., Wagga Wagga	48	Mitta Mitta R., Mitta Mitta
23	Murrumbidgee R., Narrandera	49	Mitta Mitta floodplain, Bullhead Ck.
24	Murrumbidgee R., Hay	50	Murray R., Tom Groggin
25	Murrumbidgee R., Balranald	51	Lake Eucumbene
26	Murray R., Euston	52	Lake Jindabyne

plankton. Table 3 lists macro-invertebrates commonly recorded. Most groups are recorded as components of the riverine plankton elsewhere (Hynes 1970). A detailed analysis of this drift component of the Murray zooplankton will be considered at a later date.

In Table 2, for ease of discussion, the sampling area has been divided into three major river systems, two billabong areas, and impoundments.

A greater diversity of species occurs in the billabongs, which have sheltered, still waters, abundant hydrophytes, high nutrient levels and much habitat partitioning. Eighty-three taxa of Rotifera and microcrustacea have been recorded from a single billabong near Alexandra, to date the most diverse microfaunal assemblage recorded from any freshwater habitat. It is likely that a similar complex community exists in billabongs of the Murray. The disparity between the two billabong areas studied reflects the greater intensity of sampling on the Goulburn during an earlier study (Shiel 1976).

Two major groups of microfauna are largely confined to billabongs and marginal weedbeds elsewhere — chydorid Cladocera and Ostracoda. The chydorids *Chydorus sphaericus* and *Alona rectangula*, and the ostracod *Cypretta* are frequently recorded in limno- and potamoplankton. These three taxa are regarded as facultatively limnetic (*sensu* Hutchinson 1967) and are considered with the limnoplankton. Several other chydorid species are infrequently recorded in the plankton in times of flood. These are regarded as littoral 'strays' washed out of hydrophyte beds.

Other genera predominantly recorded from billabongs, but occasionally in the plankton, are *Simocephalus*, *Ilyocryptus* and *Echinisca*. Salient points about the remaining genera are considered *seriatim* below.

Rotifera: More than 50% of the species collected remain unidentified, a reflection of the paucity of taxonomic work on the Australian Rotifera. However, many genera are predictably cosmopolitan (cf. Hutchinson 1967, Ruttner-Kolisko

TABLE 2

Species recorded in the plankton and littoral microfauna of A: *Murray river,* B: *Billabongs of the Murray floodplain between Albury-Wodonga and Yarrawonga,* C: *Goulburn River,* D: *Billabongs on the Goulburn floodplain between Eildon and Seymour,* E: *Darling River,* F: *Major impoundments.*

	A	B	C	D	E	F
Rotifera						
1. *Brachionus quadridentatus*	●	●				●
2. *B. novae zealandia*	●	●			●	
3. *B. calycifloris*	●					●
4. *Hexarthra intermedia*						●
5. *Keratella quadrata australis*	●		●	●	●	●
6. *K. valga*	●	●	●	●	●	●
7. *K. cochlearis*	●				●	●
8. *K. tropica*	●	●	●			
9. *Keratella* sp. nov.	●	●			●	
10. *Notholca* sp.	●	●		●		
11. *Euchlanis incisa*	●					
12. *Lepadella* sp.	●					
13. *Lecane luna*	●		●	●		●
14. *Asplanchna brightwelli*	●	●	●	●	●	●
15. *Polyarthra vulgaris*			●		●	●
16. *Filinia longiseta*	●	●			●	
17. *F. pejleri*	●	●			●	●
18. *Conochilus dossuarius*	●				●	●
Cladocera						
19. *Diaphanosoma excisum*			●		●	●
20. *D. unguiculatum*			●	●	●	●
21. *Latonopsis australis*		●				
22. *Pleuroxus aduncus*	●				●	
23. *Pleuroxus* sp.	●					
24. *Alonella excisa*		●		●		
25. *Chydorus sphaericus*	●	●		●		●
26. *C. eurynotus*		●				
27. *Dunhevedia crassa*		●		●		
28. *Pseudochydorus globosus*		●		●		
29. *Alona rectangula rectangula*	●	●		●		●
30. *A. rectangula richardi*				●		
31. *A. davidi davidi*		●				
32. *A. davidi iheringi*		●		●		
33. *A. cambouei*	●	●		●		
34. *A. guttata*	●			●	●	●
35. *Graptoleberis testudinaria*		●	●	●		
36. *Kurzia latissima*		●	●	●		
37. *Camptocercus australis*		●		●		
38. *Leydigia leydigii*		●		●		
39. *L. australis*	●					
40. *Biapertura affinis*		●	●	●	●	

Table 2 (continued)

	A	B	C	D	E	F
41. *B. intermedia*				●		
42. *B. kendallensis*				●		
43. *B. rigidicaudis*	●	●		●		
44. *B. karua*				●		
45. *B. setigera*		●		●		
46. *Monospilus* sp. nov.	●					
47. *Scapholeberis mucronata*		●		●		
48. *S. kingi*				●		
49. *Daphnia carinata*	●				●	●
50. *D. lumholtzi*	●	●			●	●
51. *Simocephalus exspinosus australiensis*		●		●		●
52. *S. vetulus elisabethae*		●		●		
53. *S. vetulus gibbosus*		●				
54. *S. acutirostris acutirostris*		●			●	
55. *Ceriodaphnia dubia*				●		
56. *C. laticaudata*				●		
57. *C. cornuta*	●		●		●	●
58. *C. quadrangula*	●	●	●	●	●	●
59. *Moina tenuicornis*						●
60. *M. micrura*	●	●		●	●	●
61. *Bosmina meridionalis*	●	●		●	●	●
62. *B.* cf. *longirostris*	●				●	
63. *Neothrix armata*				●		
64. *Pseudomoina lemnae*				●		
65. *Echinisca* spp.	●	●				
66. *Ilyocryptus sordidus*	●			●		
67. *I. spinifer*	●	●	●	●	●	●
68. *Macrothrix spinosa*		●		●		●
69. *Macrothrix* sp.	●					
Ostracoda						
70. *Ilyodromus ellipticus*				●		
71. *I. smaragdinus*				●		
72. *Stenocypris* sp.				●		
73. *Candona* sp. "A" sp. nov. (cf. *Cypris stobarti*)		●				
74. *Candona* sp. "B" sp. nov.				●		
75. *Candonocypris candonoides*		●				
76. *Strandesia* sp. nov.				●		
77. *Newnhamia fuscata*		●				
78. *N. fenestrata*		●				
79. *Cyprinotus leana*				●		
80. *Potamocypris* sp. nov.				●		
81. *Herpetocypris* sp.				●		
82. *Diacypris* sp. nov.				●		
83. *Ilyocypris* sp. "A"				●		
84. *Ilyocypris* sp. "B"				●		
85. *Cypretta* sp. "A" sp. nov.				●		
86. *Cypretta* sp. "B" sp. nov.				●		
87. *Cypretta* sp. "C" sp. nov.		●				
88. *Cypretta* sp. "D" sp. nov.		●				

Table 2 (continued)

	A	B	C	D	E	F
89. *Paracypria minuta*				●		
90. unidentified gen. nov. sp. nov.				●		
91. unidentified spp.	●	●	●	●		
Copepoda						
92. *Attheyella incerta*				●		
93. *A. australica*	●	●		●		
94. *Attheyella* sp. nov.		●		●		
95. *D. Arcithompsoniid* gen. nov.				●		
96. *Elaphoidella* sp.				●		
97. *Microcyclops varicans*	●	●		●		●
98. *Microcyclops* sp. 2				●		
99. *Microcyclops* sp. 3			●	●		●
100. *Microcyclops* sp. 4	●				●	
101. *Ectocyclops medius*		●		●		
102. *Eucyclops euacanthus*		●		●		●
103. *E. agilis*	●	●		●		●
104. *Eucyclops* sp.				●		
105. *Paracyclops chiltoni*		●		●		
106. *Macrocyclops albidus*		●	●	●		●
107. *Acanthocyclops vernalis*		●		●		
108. *Mesocyclops leuckarti*	●	●	●	●	●	●
109. *Mesocyclops* cf. *decipiens*						●
110. *Tropocyclops* cf. *confinus*	●	●	●	●		
111. *Tropocyclops* sp.				●		
112. *Tropocyclops* sp. nov.				●		
113. *Gladioferens spinosus*						●
114. *Calamoecia lucasi*				●	●	●
115. *C. australica*						●
116. *C. expansa*				●		●
117. *C. ampulla*	●				●	●
118. *Hemiboeckella searli*				●		
119. *Boeckella minuta*		●		●		
120. *B. major*						●
121. *B. fluvialis*		●	●	●	●	●
122. *B. delicata*						●
123. *B. triarticulata*	●	●	●	●	●	●
Amphipoda						
124. *Austrochiltonia australis*		●		●		
Isopoda						
125. *Heterias* sp.				●		
Decapoda						
126. *Paratya australiensis*	●	●		●		
127. *Macrobrachium* sp.	●	●				

TABLE 3
MACRO-INVERTEBRATES COMMONLY COLLECTED IN THE MURRAY-DARLING PLANKTON

Taxon	Predominant groups(s)
Coelenterata	Hydrozoa – *Chlorohydra, Hydra, Craspedacusta sowerbyi*
Platyhelminthes	Turbellaria
Aschelminthes	Gastrotricha, Nematoda
Mollusca	Bivalvia – glochidia of the Murray River mussel, *Velesunio ambiguus* and/or *Alathyria jacksoni*
Annelida	Naididae – *Chaetogaster* sp.
Arthropoda	Tardigrada
	Insecta – Collembola
	Ephemeroptera)
	Odonata) – nymphal stages
	Plecoptera)
	Hemiptera – Belostomatidae, Notonectidae, Corixidae
	Coleoptera – Dytiscidae, Gyrinidae, Hydrophilidae
	Trichoptera – Hydroptilidae (nymphs)
	Diptera – Chironomidae
	Arachnida – Hydracarina, Porohalacaridae

1974). Ten of the eighteen species are listed by Whitton (1975) as common river zooplankton. Notably, eight of the Murray rotifer species (species code 1, 4, 5, 6, 7, 14, 15, 16 in Table 2) are recorded by Whitton as indicators of eutrophic conditions in rivers. Several of these species are common in Lake Hume, where conditions verging on eutrophy have been documented (Gutteridge, Haskins & Davey 1974).

Cladocera: Of the 51 species recorded, eleven are regarded as true plankters (19, 20, 49, 50, 57, 58, 60, 61, 62) or facultatively planktonic (25, 29). The seasonal occurrence of *Macrothrix* (69) in the lower Murray is noted. This is normally a littoral genus (Hutchinson 1967). Its presence in the plankton may be a response to algal blooms, high turbidity and the low flow after the dry summer of 1976-77 which brought about 'pond' conditions. All other planktonic species were recorded from upstream impoundments and river tracts, and seven of the eleven occur in Lake Alexandrina at the Murray mouth (M. C. Geddes, pers. comm.). All genera recorded are common to both lakes (Hutchinson 1967) and rivers (Whitton 1975).

Copepoda: The Harpacticoida recorded are littoral forms rarely occurring in the plankton. The cosmopolitan cyclopoid genera *Mesocyclops, Eucyclops* and *Microcyclops* are all represented in the potamoplankton. Of the calanoid copepods listed, only two species occurred throughout the basin (*C. ampulla* and *B. triarticulata*). However, some species were recorded over wide areas (*C. lucasi, B. fluvialis*); others had limited distributions (*C. expansa, C. australica, B. delicata, B. major*).

Distributional differences in plankton assemblages are indicated by Fig. 2, which shows autumn limnoplankton composition in ten selected impoundments. In seven of these, the limnoplankton was dominated by Copepoda, predominantly *C. ampulla, B. triarticulata* and cyclopoid copepodites. Copepoda were also present in the other three impoundments, but the cladoceran *Bosmina* dominated in Eildon (35); a dinoflagellate, *Ceratium*, predominated in Burrendong (16; also present in large numbers in Hume, 44); and seven species of rotifers comprised 60% of the plankton in Menindee (9; especially *Filinia longiseta* and *Keratella quadrata australis*).

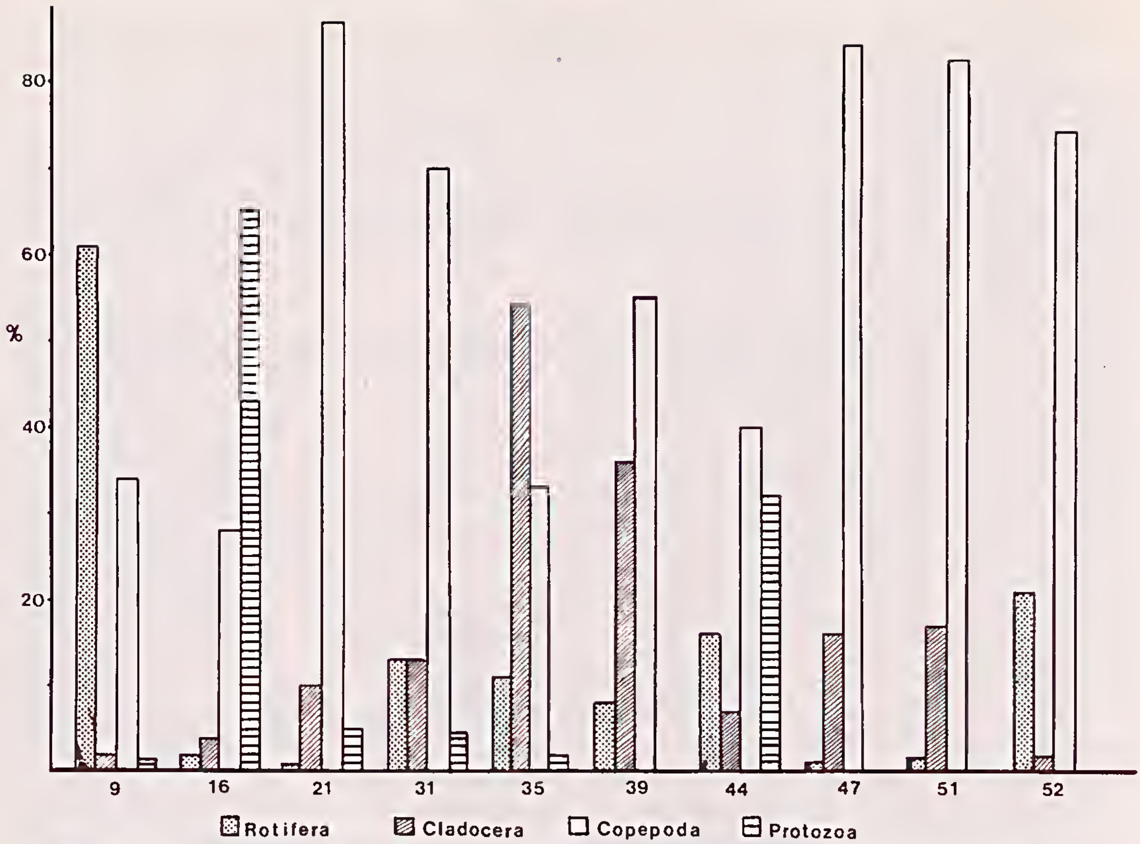

FIG. 2 — Comparative limnoplankton composition (%) of ten selected impoundments in autumn, 1977. See Table 1 for localities.

Plankton densities varied from < 20 — 30 l^{-1} in the nutritionally dilute alpine lakes to > 200 l^{-1} in Hume and Burrendong.

In the case of Lake Menindee, its extreme shallowness (< 3 m), turbidity (< 10 cm transparency), and its 'riverine' features may have contributed to the differences in plankton. Differences in nutrient levels may account for the compositional changes in Hume and Burrendong, but comparative data are lacking.

The occurrence of lacustrine assemblages below the dams varies seasonally and with individual impoundments, depending on the output from the dam. In Lake Eildon, for example, the outlet to the power station is at 52 m in the hypolimnion (I. J. Powling, pers. comm.). When the lake stratifies in summer, plankters are absent from the deoxygenated hypolimnion, and consequently are absent from the outfall below the dam. After overturn in May/June, plankters may survive passage through the turbines. In the winter of 1974, when Eildon overflowed, and the spillway gates were opened, a lacustrine plankton was collected in the pondage below the dam, and lake species were recorded from the flooded billabongs at Alexandra, 20 km downstream (Shiel 1976). The 1974-75 flooding did not, however, significantly flush the Alexandra billabong fauna into the Goulburn. The moderating effect of Eildon reservoir, gentle downstream gradients and relatively wide floodplain allowed a slow rise in water level which led to lateral movement of the zooplankton populations into fringing *Juncus* beds, with protection from the minimal current flow (Shiel 1974).

This flood-mitigating feature of impoundments has undoubtedly promoted the maintenance of a lacustrine plankton. Below Hume, Lake Mulwala provides relatively still waters, extensive backwaters, and littoral weedbeds. Below Eildon, complex plankton communities are found in the Goulburn Weir at Nagambie, and Lake Victoria at Shepparton.

Significantly, the Darling, the least impounded of the major rivers in the system, has a plankton composition numerically dominated by Rotifera, and most closely approximating the rotifer-dominated riverine assemblages noted by Hynes (1970) and Whitton (1975).

The contribution in flow of the Darling to the lower Murray varies markedly. The greatest proportion of flow to the lower Murray is from the Murray-Goulburn catchment, with seasonal peaks from the Darling. Two such flood peaks occurred in summer, 1976, and autumn, 1977.

Below the confluence of the two rivers at Wentworth there are no significant tributaries. Zooplankton assemblages recorded in the lower Murray reflect, therefore, the contributions from each system and the seasonal fluctuations therein. The mixing of the two inputs produces a zooplankton assemblage which persists for about 500 km to Lake Alexandrina. Low gradients (1 — 2 cm per km) and significant nutrient inputs from downstream towns and irrigation areas contribute to produce a slow-moving series of more or less discrete 'slugs' of water in which algal blooms are frequent. Nuisancc blooms of *Anabaena, Melosira, Microcystis* and *Oscillatoria* are most common. The zooplankton composition of each 'slug' varies with source, temperature and perhaps food availability.

Fig. 3 shows the fluctuation in zooplankton composition recorded at Mannum over a period of 16 months. Cladocera and Copepoda, predominantly *Bosmina meridionalis, Ceriodaphnia quadrangula* and *Boeckella triarticulata*, dominate the plankton, with seasonal occurrences of *Moina micrura* and *Ceriodaphnia cornuta*. Two peaks of Rotifera (*Brachionus quadridentatus* and *Keratella valga*) were noted in summer and autumn, coinciding with floodwaters from the Darling. Only two rotifer species were frequently collected over the study period — *Asplanchna brightwelli* and *Keratella quadrata australis*.

Domination of the zooplankton by Cladocera and Copepoda suggests that the Murray has characteristics of both lotic and lentic systems, characteristics which may change seasonally. Hynes (1970) noted that crustaceans, important in still waters, are rarely important in rivers, where rotifers dominate. He also noted (1969) the poor development of the plankton generally, as compared with still waters. Neither statement strictly applies to the Murray.

In studies on the Nile, Monakov (1969) and Rzoska (1976) noted that increasing impoundment of the river favours the development and maintenance of lake plankters in the river. Many of the cosmopolitan rotifer and microcrustacean species collected in the Murray system are recorded from Nile impoundments; however, cataracts and rapids on the latter system have a devastating effect in selectively removing plankters. Similarly, the scasonal flooding of the Nile system largely obliterates the plankton (Rzoska 1976). These effccts are not seen in the Murray-Darling, with gentler physiography and lower rainfall. Seasonal dilution of the Murray plankton occurs in times of

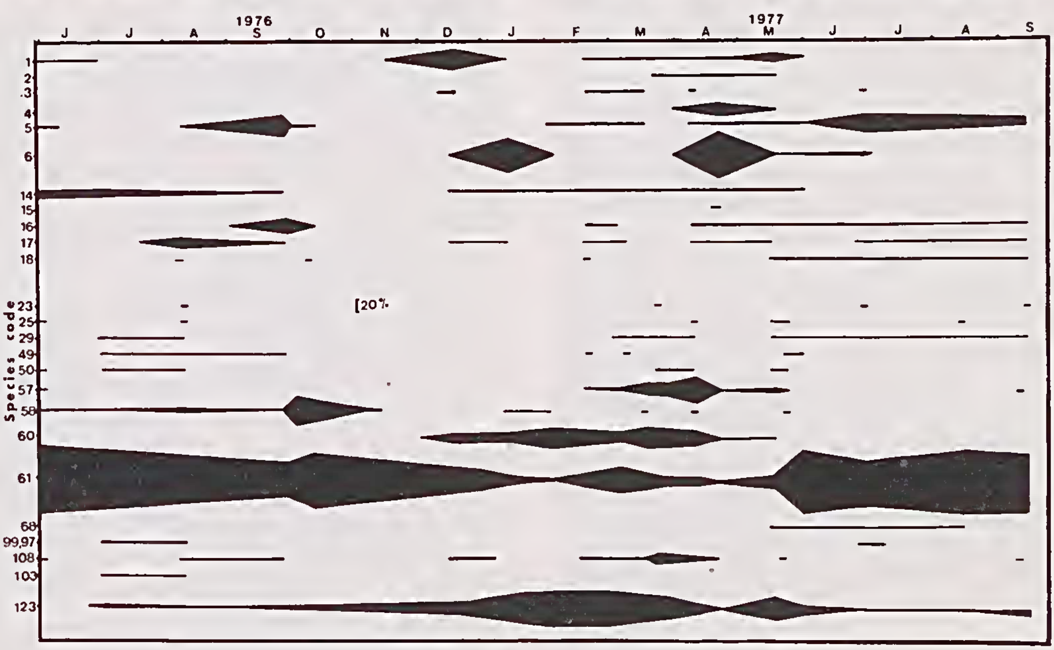

FIG. 3 — Seasonal compositional changes in riverine plankton at Mannum, S.A. See Table 2 for species code.

flood, but there is little elimination of plankters. Diversity actually increases as plankton of back-waters and non-planktonic inhabitants of billabongs are washed into the river.

In summary, the composition of the zooplankton of the lower Murray is closer to that of upstream impoundments than to a true riverine plankton. Indeed, it more closely resembles the community of permanent ponds. The plankton of such ponds in Australia generally includes *Boeckella triarticulata, Mesocyclops leuckarti, Daphnia lumholtzi, D. carinata, Ceriodaphnia cornuta, Alona rectangula, Chydorus sphaericus* and *Asplanchna.* All of these species are recorded from a variety of ponds (as well as lakes, impoundments and billabongs) in eastern Australia (Jolly 1968, Timms 1970a, b, 1973, Bayly & Williams 1973, Shiel 1976). Their widespread distribution in such diverse habitats suggests adaptation to a range of physico-chemical and biological parameters, the extremes of which are not exceeded in the Murray-Darling System.

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